

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11)

EP 1 102 430 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
23.05.2001 Bulletin 2001/21

(51) Int Cl.7: **H04L 9/32, H04L 12/28,**
H04B 7/26

(21) Application number: **99850158.9**

(22) Date of filing: **27.10.1999**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(72) Inventors:
• **Gehrmann, Christian**
112 52 Stockholm (SE)
• **Blom, Rold**
175 68 Järfälla (SE)

(71) Applicant: **TELEFONAKTIEBOLAGET LM**
ERICSSON
126 25 Stockholm (SE)

(74) Representative: **Hytting, Kerstin Cecilia et al**
Dr. Ludwig Brann Patentbyrå AB,
P.O. Box 171 92
104 62 Stockholm (SE)

(54) Method and arrangement in an ad hoc communication network

(57) The present invention relates to the requirement of security in an ad hoc network. More particularly it relates to the problem within ad hoc networks, not having on-line connections to a particular server for getting desired public keys or certificates, required to create trust relations.

Within an ad hoc communication network, some of

the nodes have a mutual trust relation to each other, thus constituting a trust group. An additional node within the network is being a candidate node for joining the trust group. An X-node is identified, being a member of a trust group and having a trust relation with the candidate node. The X-node distributes trust relations between the members of the trust group and the candidate node.

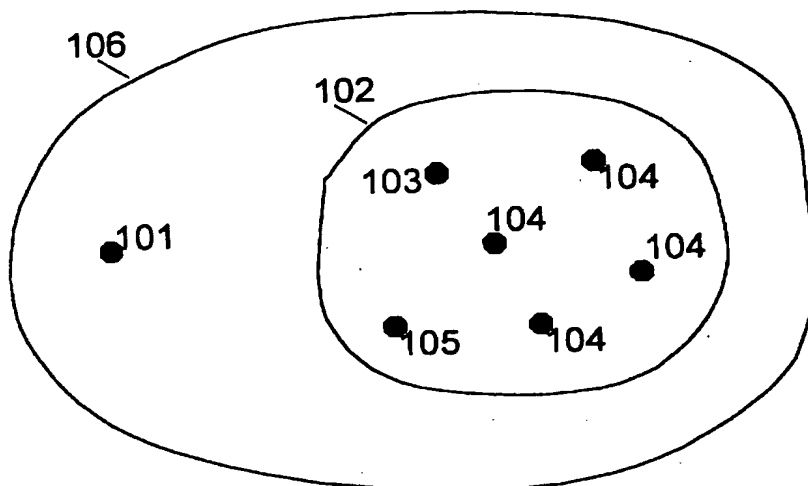


Fig. 1

Description

FIELD OF INVENTION

[0001] The present invention relates to the field of communication networks and more specifically to an ad hoc communication network and a method for establishing security in an ad hoc network

DESCRIPTION OF RELATED ART

[0002] The fast growth of open networks with easy access has raised many security problems. Several security solutions for public networks like the Internet have appeared. Security is a problem in all kinds of open networks both wired and wireless. Information transmitted over the air is extremely vulnerable. Today there exist solutions that are built upon some type of so called *public key infrastructure* (PKI). A public key infrastructure is a system used to distribute and check public keys that can be used to authenticate users, exchange session keys, sign information or encrypt information.

[0003] In a PKI system, two corresponding (also called asymmetric) keys are used in connection with protecting information. Information, which is encrypted with one of the two keys, can be decrypted only with the other key. In some PKI systems either of the two keys can be used to encrypt and the other to decrypt. In other systems, one key must be used only for encryption and the other for decryption. One important feature of PKI systems is that it is computationally unfeasible to use knowledge of one of the keys to deduce the other key. In a typical PKI system, each of the systems possesses a set of two such keys. One of the keys is maintained private while the other is freely published. If a sender encrypts a message with the recipient's public key, only the intended recipient can decrypt the message, since only the recipient is in possession of the private key corresponding to the published public key. If the sender, before performing the above encryption, first encrypts the message with the sender's private key, the recipient, upon performing first a decryption, using the recipient's private key, then a decryption on the result, using the sender's public key, is assured not only of privacy but of authentication since only the sender could have encrypted a message such that the sender's public key successfully decrypts it. In one digital signature scheme, one-way hash is first applied to a message and the hash of the message is encrypted with the sender's private key.

[0004] A PKI distributes one or several public keys and determine whether a certain public key can be trusted for certain usage or not. A piece of digitally signed information is often called a certificate. Certificates are the basis upon which PKIs are built.

The degree of confidence that the recipient has in the source of a message depends on the degree of the recipient's confidence that the sender's public key corre-

sponds to a private key that was possessed only by the sender. In many current systems, a number of generally well trusted certification authorities have been established to provide this degree of confidence.

5 A common certificate format is Standard X.509 (developed by the International Standards Organisation (ISO) and the Comité Consultatif Internationale Telegraphique et Telephonique (CCITT)). Such a certificate may, e.g., include a public key, the name of subject who possesses
10 or is associated with the public key, an expiration date, all of which are digitally signed by a trusted party. The digital signature may be provided e.g., according to the digital signature standard (DSS) (National Institute of Standards and Technology (NIST)). Typically a digital
15 signature involves applying a one-way hash and then encrypting with the private key of, in this case, the certification authority. Such digital signature is provided using the private key of the trusted party which, in turn, is authenticated using the trusted party's certificate signed
20 by yet another trusted party, so that there may be a multi-level hierarchy of trusted parties.

Another certificate format is Pretty Good Privacy (PGP) developed by P. Zimmermann and described in Internet Engineering Task Force (IETF) Open PGP Specification. PGP provides a way to encrypt and decrypt, sign
25 data and exchange keys. Thus it is more than just a PKI. However, the main idea with PGP is that no strict PKI is needed. Instead the PGP users themselves create and extend the PKI they need. This is done by certifying other users public keys, i.e., signing trusted public keys with
30 their own secret key. In this way a "web of trust" is created. A particular key may have several different user IDs. Typically a user ID is an email address. If a revocation signature follows a key, the key is revoked. A user
35 certifies another users key by signing it with one of the keys of his own, which has signing capability. When signing another key, different trust levels can be set, i.e., the amount of confidence the signer has in the signed key and user ID.

40 [0005] Today, so-called ad hoc networks are used more and more frequently. An ad hoc network is established temporary for a special purpose. There is no fixed infrastructure, the nodes are the network. The nodes within the network are often mobile and using radio links.
45 An ad hoc network might constitute dynamic wide area connectivity in situations such as military operations, rescue and recovery operations, and remote construction sites. An ad hoc network might also constitute local area connectivity in situations such as temporary conference sites, home networks and robot networks. An
50 ad hoc network might also constitute personal area networks in situations such as interconnected accessories, ad hoc conference table and games. The nodes might consist of e.g. mobile phones, lap tops, television sets,
55 washing machines. In some situations like in military operations or business conferences when the communication between the nodes comprises secrets, it is very important that a sender of a message can trust that the

receiver really is the intended receiver.

[0006] In the previous examples, bindings between public keys and names or authorisation are described. Several of these certificate solutions exist in different systems. However, it is not yet described how different certificates needed for different kinds of purposes are obtained. In the case of ordinary X.509 type of PKI with hierarchical Certificate Authority (CA) structures, finding the right certificate is done using some central on-line server or by direct transmission of the certificate at connection set up. When using PGP either the desired public key is stored locally on a machine or the device has to make a connection to a central PGP server in order to find the desired public key. This works if it is possible for entities that need some type of security relation to have on-line connections to some particular servers. This is not the case for ad hoc networks. Ad hoc networks are created on the fly between entities that happen to be at the same physical location.

[0007] Therefore, what is further needed is a mechanism for checking if different nodes in an ad hoc network share a trust relation and for creating trust among a certain set of nodes without any pre-defined relations.

[0008] The problem of how to distribute trust using public keys in ad hoc networks is addressed in this invention. Still the existing PKIs provide a basis upon which solution also for ad hoc network can be built.

SUMMARY OF THE INVENTION

[0009] The present invention relates to the requirement of security in an ad hoc network. More particularly it relates to the problem within ad hoc networks, not having on-line connections to a particular server for getting desired public keys or certificates, required to create trust relations.

[0010] Accordingly, it is an object of the present invention to unravel the above-mentioned problem.

[0011] The aforesaid problem are solved by means of a method for finding possible trust relations between nodes within the ad hoc network and share them with other nodes within the ad hoc network.

[0012] The following scenario of establishing security in an ad hoc network describes the inventive concept of the present invention.

[0013] Within an ad hoc communication network, some of the nodes have a mutual trust relation to each other, thus constituting a trust group. A node within the network is being a candidate node for joining the trust group. An X-node is identified, being a member of a trust group and having a trust relation with the candidate node. The X-node distributes trust relations between the members of the trust group and the candidate node.

[0014] An advantage of the present invention is it is possible to achieve the necessary security associations needed for distributing and sharing information among a group of users that happens to be at the same physical location. There are a large amount of applications that

fits in to this scenario. Among those can be mentioned people from different companies or organisations that gather in a conference room can share documents with the meeting members.

5 [0015] Another advantage of the present invention is that the number of manually created trust relations between members in an ad hoc communication network is decreased.

10 [0016] Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

- Figure 1 shows a scenario where a single node establishes trust with an existing trust group within a communication network.
- 25 Figure 2 shows a scenario where trust is established in an ad hoc communication network.
- Figure 3 shows a scenario where trust is established in an ad hoc communication network.
- 30 Figure 4 shows a scenario where two trust groups within an ad hoc communication network are merged.
- Figure 5 shows a scenario where two trust groups within an ad hoc communication network are merged.
- 35 Figure 6 shows a scenario where two trust groups within an ad hoc communication network are merged.
- 40 Figure 7 shows a scenario where two trust groups within an ad hoc communication network are merged.

DESCRIPTION OF PREFERRED EMBODIMENTS

45 [0018] The ad hoc communication network according to the invention constitutes e.g. a bluetooth network. The ad hoc network comprises nodes constituting e.g., laptops and mobile phones, each node comprising a receiver and a computer, the computer comprising a processor and a memory. The nodes are interconnected via communication links.

50 [0019] Figure 1 shows a possible scenario of the present invention in which a single node 101 is added to an existing trust group 102. The trust group 102 comprises nodes 103-105. All the nodes 103-105 in the trust group 102 have mutual trust relations with each other, the trust relations being created with trusted public keys. Thus each node 103-105 in the trust group 102 has the

trusted public keys of all the other nodes 103-105 within the trust group 102. The trusted public keys are e.g. used to sign messages to be sent between trusted nodes. The single node 101 and the trust group constitute an ad hoc communication network 106. According to the invention all nodes 101, 103-105 have authority to delegate trust to other nodes that they trust within the network. The single node 101 would like to join the trust group 102 and the single node is from now on called the candidate node 101.

[0020] Either the candidate node 101 sends a broadcast message to all the nodes 103-105 within the trust group or it unicasts message to a special look up server where all the nodes 103-105 can obtain the message. The message comprises the public key that the candidate node 101 wants to use. The message might comprise a set of public keys that the candidate node 101 wants to use and possible certificate/s certifying the public key/s.

[0021] Each node 103-105 within the trust group 102 obtains the public key of the candidate node 101, and checks if it trusts the public key of the candidate node.

[0022] A node 103 within the trust group that trusts the public key of the candidate node 101 is identified, a so-called X-node 103. The X-node,

- sends a signed message comprising all the trusted keys of the nodes 103-105 within the trust group 102 to the candidate node 101, and
- signs the public key of the candidate node 101 and sends a message comprising the key together with the signature to all the other nodes 104, 105 within the trust group 102.

[0023] If none of the nodes 103-105 within the trust group 102 trusts the candidate node a trust relation has to be manually created with an arbitrary node 105 within the trust group 102. This node 105 thus constitutes an X-node. A manual creation of trust relation between two nodes can be performed in different ways. In one way the two nodes enter their pin codes and then exchange public keys using an authenticated channel. The manual creation of trust relations results in that each node obtains a trusted public key from the other party.

[0024] After the manual creation of trust, the X-node 105

- sends a signed message comprising all the trusted keys of the nodes 103-105 within the trust group 102 to the candidate node 101, and
- signs the public key of the candidate node 101 and sends a message comprising the key together with the signature to all the other nodes 103, 104 within the trust group 102.

[0025] Figure 2 shows another scenario of the present invention. In this scenario an ad hoc communication network 201 is formed. The trust groups 202, 203,

204 and 205 within the ad hoc network are used to create additional trust relations within the network. The trust relations are created with signed public keys. The ad hoc network comprises nodes A-M. In this embodiment, each of the nodes A-M constitutes a node being a candidate for joining a secure ad hoc network. Le., a trust group wherein all nodes A-M have mutual trust relations.

[0026] The nodes A, B, C, D and E have mutual trust relations and constitute a trust group 202.

[0027] The nodes D, E, G, J and K have mutual trust relations and constitute a trust group 203.

The nodes A, E, F and I have mutual trust relations and constitute a trust group 204.

[0028] The nodes H and M have mutual trust relations and constitute a trust group 205. The node L has no trust relations to any of the other nodes within the network.

[0029] As shown in figure 2, the node E belongs to three trust groups 202, 203 and 204. The node D and E belong to two trust groups, 202 and 203. The nodes A and E belong to two trust groups 202 and 204.

[0028] According to the invention all nodes A-M have authority to delegate trust to other nodes that they trust, within the network. 201.

[0029] Each node A-M within the ad hoc network 201 sends a broadcast message to all the nodes A-M within the ad hoc network 201 or a unicast message to a special look up server where all the nodes A-M can obtain the message. The message comprises the public key that the candidate node A-M wants to use. The message might comprise a set of public keys that the candidate node wants to use and possible certificate/s certifying the public key/s.

[0030] Each of the nodes A-M obtains the public keys of all the other nodes A-M, either they are trusted or untrusted. Each node A-M then creates a list of its trusted nodes and their corresponding keys. E.g. node A which belongs to trust group 202 trusts the nodes B, C, D and E.

[0031] In this scenario, one node A is decided to act as a server node A. Each of the nodes B-M, sends a registration message to the server node A comprising its public key and the list of its trusted nodes and their corresponding public keys.

[0032] Using the obtained information the server node A identifies all the nodes A-M and the trust groups 202-205 within the ad hoc network.

[0033] Server node A might find that some nodes or some trust groups are isolated, i.e. neither having a trust relation with the server node A nor having a trust relation with any of the nodes that A has a trust relation with. In this embodiment that goes for node L and trust group 205 comprising the nodes H and M.

[0034] In that case server node A asks the node L, to manually create a trust relation with the server node A. Server node further A asks one node H in that trust group 205, to manually create a trust relation with the server node A. This results in two more trust groups and is illustrated in figure 3. The nodes A and L constitutes

trust group 301 and the nodes A and H constitutes trust group 302.

[0035] The server node A classifies all the nodes within the ad hoc network as being nodes that the server node A trusts, nodes B, C, D, E, F, I, H and L, i.e. server-trusted nodes, or as being nodes that server node A not trust, nodes G, J, K and M, i.e. server-untrusted nodes. The server node A then makes a list comprising the server-untrusted nodes, the so-called untrust-list.

[0036] A server-trusted node trusting a server-untrusted node constitutes a so-called Y-node. The server node A identifies as many Y-nodes as required for distributing trust relations to all or as many as possible of the server-untrusted nodes. i.e. server node A identifies node D, having trust relations with nodes G, K and J, and node H having a trust relation with node M. Thus node D and node H can distribute trust relations between all the server-untrusted nodes and server node A according to the following process:

[0037] The server node A sends a message to the identified Y-nodes, the message comprising,

- the untrust-list comprising the nodes G, J, K and M and their corresponding public keys, and
- a request of distributing as many trust relations as possible between server node A and server-untrusted nodes.

[0038] An Y-node obtains the message and checks, which of the keys it trusts, i.e. which of the server-untrusted nodes G, J, K and M the Y-node trusts.

[0039] The identified Y-nodes then each perform the following steps 1-3 for each of the nodes that the respective Y-node trusts. In this case the Y-node D performs the steps for each of the nodes G, J and K and Y-node H performs the steps for node M.

1. The Y-node signs the public key of server node A and sends it to the node that the Y-node trusts, e.g. Node D signs server node A's key and sends it to node G,
2. The Y-node signs the public key of the node that the Y-node trusts and sends it to server node A, e.g. Node D signs node G's key and sends it to server node A.
3. Server node A reclassifies the node that the Y-node trust, and that the server node A now trusts, as now being a server-trusted node, and the untrust-list is reduced with said node, e.g. server node A reclassifies node G as being a server trusted node and the untrust-list is reduced to J, K, and M.

[0040] The distribution of trust relations is now completed and the untrust-list is empty. Server node A has collected signed public keys from all nodes B-M within the ad hoc network 201 and sends a message to all nodes B-M comprising server node A's collected signed public keys from all the nodes B-M within the ad hoc

network.

[0041] The nodes A-M within the ad hoc communication network 201 now have mutual trust relations and a secure ad hoc network is established.

[0042] Figure 4 shows yet another scenario of the present invention. In this scenario an ad hoc network 401 comprises two trust groups 402 and 403 which shall be merged to one trust group constituting a secure ad hoc network. The first trust group 402 comprises a set of nodes, N, O, P, Q and R, all having mutual trust relations. The second trust group 403 comprises a set of nodes, S, T, U, V and W, all having mutual trust relations and which all are candidate nodes for joining the first trust group 402. The trust relations are created with trusted public keys. A node P is decided to act as a server node P within the first trust group 402 and a candidate node S is decided to act as a server node S within the second trust group. According to the invention, the nodes N-W are authorised to delegate trust relations to other nodes within the network that it trusts.

[0043] Server node S sends a message, comprising a list of all candidate nodes S, T, U, V and W within the second trust group 403 and their corresponding public keys, to server node P. First server node P checks if it trusts any of the obtained keys, i.e. if it has trust relations to any of the candidate nodes S, T, U, V and W. First server node P, then classifies the candidate nodes as being first server-trusted nodes or as being first server-untrusted node, in this case P-trusted or P-untrusted.

[0044] If the classification results in at least one first server-trusted node, a scenario comes up as illustrated in figure 5. In this scenario first server node P has a trust relation to the node W and first server node P sends a message to second server node S. The message comprises

- a list of all nodes N, O, P, Q and R within the first trust group 402 and their corresponding public keys, and
- a list of first server-trusted nodes, which in this case is the P-trusted node W, and its corresponding public key.

[0045] Second server node S obtains the message and signs it and forwards it to node W.

[0046] Node W receives the signed message and checks the signature of the message. If node W trusts the signature, node W

- signs the received public keys of the nodes N, O, P, Q and R within the first trust group 402,
- sends a signed message comprising the signed public keys of the nodes N, O, P, Q and R within the first trust group 402 to all candidate nodes S, T, U and V within the second network,
- sends a signed message comprising all trusted public keys of the candidate nodes S, T, U, V and W to first server node P.

[0047] First server node P receives the message and checks the signature of the message. If it is valid, first server node P signs the public keys of the candidate nodes S, T, U, V and W within the second trust group 403 and sends them in a signed message to all nodes N, O, Q and R.

[0048] The nodes N-W within the ad hoc network 102 now have mutual trust relations and a secure ad hoc communication network is established.

[0049] In another scenario, shown in figure 6, the classification is resulting in no first server-trusted node i.e. a P-trusted node. This means that first server node P has no trust relation with any of the candidate nodes S, T, U, V and W. Server node P then asks the other nodes N, O, Q and R within the first trust group 402, one by one, until sever node P obtains a positive answer of the question, if they have a trust relation with any of the candidate nodes S, T, U, V and W, within the second trust group 403.

[0050] In this case, node N has no such trust relation, the query is forwarded to node O, which has not got such trust relation either. The query is forwarded to node Q, which has a trust relation with node V in the second trust group, and now the procedure of distributing trust can start

[0051] Node Q sends a signed message to second server node S. The message comprises:

- a list of all nodes N, O, P, Q and R within the first trust group 402 and their corresponding public keys,
- a list of the nodes that node Q trusts, which in this case is the node V, and its corresponding public key.

[0052] Second server node S obtains the message and forwards it to node V.

[0053] Node V receives the signed message and checks the signature of the message. If node V trusts the signature, it signs the received public keys of the nodes N, O, P, Q and R within the first trust group 402. Node V then sends a signed message comprising the signed public keys of the nodes N, O, P, Q and R within the first trust group 402 to all candidate nodes S, T, U and W within the second network. Node V sends a signed message comprising all trusted public keys of the candidate nodes S, T, U, V and W to node Q.

[0054] Node Q receives the message and checks the signature of the message. If it is valid, node Q signs the public keys of the candidate nodes S, T, U, V and W within the second trust group 403 and sends the keys in a signed message to the other nodes N, O, P and R within the first trust group 402.

[0055] The nodes N-W within the ad hoc network 102 now have mutual trust relations and a secure ad hoc communication network is established.

[0056] In yet another scenario, none of the nodes N, O, P, Q and R, within the first trust group 402, have a trust relation with any of the candidate nodes S, T, U, V and W, within the second trust group 403. In this case

a message is returned to first server node P asking node P to manually create a trust relation with the second server node S. This scenario is illustrated in figure 7. First server node P and second server node S now constitute a trust group 701.

[0057] First server node P sends a message to second server node S. The message comprises a list of all nodes N, O, P, Q and R, within the first trust group 402, and their corresponding public keys.

[0058] Second server node S

- signs the received public keys of the nodes N, O, P, Q and R within the first trust group 402,
- sends a signed message comprising the signed public keys of the nodes N, O, P, Q and R within the first trust group 402 to all candidate nodes S, T, U and V within the second network,
- sends a signed message comprising all trusted public keys of the candidate nodes S, T, U, V and W to first server node P.

[0059] First server node P receives the message and checks the signature of the message. If it is valid, first server node P signs the public keys of the candidate nodes S, T, U, V and W within the second trust group 403 and sends them in a signed message to all nodes N, O, Q and R.

[0060] The nodes N-W within the ad hoc communication network 102 are now having mutual trust relations and a secure ad hoc network is established.

Claims

1. Method for establishing security in an ad hoc communication network (106), the ad hoc network (106) comprising a set of communication nodes (101, 103-105) whereof at least two of the nodes (103-105) having a mutual trust relation and thus constituting a trust group (102), the trust relations being created with public keys, and at least one additional node (101), being a candidate for joining the trust group (102) within the ad hoc network (106), characterised by the nodes having authority to delegate trust to nodes they trust, the method comprising the steps of

- a) identifying a node (103) within the trust group having a trust relation with the candidate node (101), a so-called X-node (103);
- b) distributing trust relations between all the members in the trust group (102) and the candidate node (101) by means of the X-node (103).

2. The method of claim 1, characterised by comprising the further step to be taken before step a), the candidate node (101) sending a message, compris-

ing its public key, to all nodes (103-105) within the network.

3. The method of any of the previous claims, **characterised** in that the ad hoc network (106) comprises a single trust group (102), and a single candidate node (101), wherein step b), implies that the X-node (103) sends a signed message, comprising a list of the nodes (104, 105) that the X-node (103) trusts within the ad hoc network (106), and all their corresponding public keys, to the candidate node (101). 5
4. The method according to any of the previous claims, **characterised** in that step b) further implies that the X-node (103) signs the candidate node's (101) public key. 10
5. The method according to the previous claim, **characterised** in that step b) further implies, the X-node (103), sends a message, comprising the candidate node's (101) signed public key, to the nodes (104-105) within the trust group (102). 15
6. The method according to claim 2 **characterised** in that the ad hoc network (201) comprises a set of nodes (A-M) comprising several trust groups (202-205), and all nodes (A-M) being candidates for joining all trust groups, within the ad hoc network, that they are not already a member of, the method comprising the further step to be taken, by each node (A-M), after receiving the messages from all candidate nodes (A-M), creating a list of the candidate nodes that the particular node trusts and their corresponding public keys. 20
7. The method according to the previous claim, **characterised** by further comprising the step of deciding one node (A) within the ad hoc network (201) to act as a server node (A). 25
8. The method according to any of the claims 6-7, **characterised** by further comprising the step of, the server node (A) receiving from each other node (B-M) within the network, a message comprising its respective public key, the respective list of the candidate nodes that the respective node trust and their corresponding public keys. 30
9. The method according to the previous claim, **characterised** by further comprising the step of, the server node (A) *classifying* the at least one candidate node as being a server-trusted node (B, C, D, E, F and I) or as being a server-untrusted node (G, H, J, K, L and M), depending on whether the server node (A) trusts it or not. 35
10. The method according to the previous claim, where- 40

in a server-trusted node trusting a server-untrusted node constitutes a so-called Y-node, **characterised** in that the step a) implies that the server node (A) identifies at least one Y-node required for distributing trust relations between the server node (A) and as many server-untrusted nodes as possible.

11. The method according to the previous claim, **characterised** in step b) further implying that server node (A) sends a request to the identified Y-nodes (D, H) of distributing said trust relations between server node A and server-untrusted nodes. 45
12. The method according to the previous claim, **characterised** in step b) further implying that server node (A) obtains said requested trust relations. 50
13. The method according to the previous claim, **characterised** in, the step of obtaining the trust relations comprising that for each server-untrusted node that the Y-node have a trust relation with, the Y-node signs the public key of the server node (A) and forwards it to the server-untrusted node. 55
14. The method according to any of the claims 12-13, **characterised** in the step of obtaining the trust relations comprising that for each server-untrusted node that the Y-node have a trust relation with, the Y-node signs the public key of the server-untrusted node and forwards it to the server node (A).
15. The method according to any of the claims 12-14, **characterised** by comprising the further step of, server node (A), after obtaining said trust relation, reclassifying the server-untrusted node with the obtained trust relation as being a server-trusted node.
16. The method according to any of the claims 12-15, **characterised** by comprising the further step of, server node (A) sending a signed message comprising the server node's (A) all trusted public keys belonging to trusted candidate nodes within the ad hoc network. (201).
17. An ad hoc communication network (106) comprising a set of communication nodes (101, 103-105) whereof

the nodes (101, 103-105) each comprising a receiver and a computer, the computer comprising a processor and a memory, the nodes (101, 103-105) being interconnected with communication links, at least two of the nodes (103-105) are having a mutual trust relation and thus constituting a trust group (102), the trust relations being created with public keys, and at least one additional node (101) being a can-

didate for joining at least one trust group (102) within the ad hoc network,

characterised by

the candidate node (101) having means for requesting if any of the nodes within the trust group (102) have a trust relation with the candidate node (101),
the nodes being authorised to and are having means for, distributing trust relations between its trust group(102) and the candidate node (101) that it trusts.

18. The ad hoc communication network (201) according to the previous claim, **characterised** by each node (A-M) having means for creating a list of the candidate nodes that the node trusts and their corresponding public keys, to be stored in the memory.

19. The ad hoc communication network according to any of the claims 17-18, **characterised** in that one node (A) within the ad hoc network (201) being a server node (A), capable of administrate distribution of trust relations.

20. The ad hoc communication network (201) according to the previous claim, **characterised** by the server node (A) having means for classifying the at least one candidate node as being a server-trusted node (B, C, D, E, F and I), or as being a server-untrusted node (G, H, J, K, L and M), depending on whether the server node (A) trusts the candidate node or not.

21. The ad hoc communication network (201) according to the previous claim, wherein a server-trusted node trusting a server-untrusted node constitutes a so-called Y-node **characterised** by the server node (A) having means for identifying at least one Y-node (D, H) required for distributing trust relations between the server node A and the server-untrusted nodes.

22. The ad hoc communication network (201) according to the previous claim **characterised** by the server node (A) having means for sending to each of the identified Y-nodes (D,H),

a request as to which of the server-untrusted nodes (G, H, J and M) the Y-node (D,H) has a trust relation with, and
a request for distributing trust relations between the server node (A) and the requested server-untrusted nodes.

23. The ad hoc communication network according to any of the claims 20-22, **characterised** by the serv-

er node (A) having means for distributing obtained trust relations to the nodes within the ad hoc communication network (201).

5 24. A computer program product directly loadable into the internal memory of a digital computer within a node being a member of an ad hoc communication network, comprising software code portions for performing the steps of any of the claims 1-16 when said product is run on a computer.

10 25. A computer program product stored on a computer usable medium, comprising readable program for causing a computer, within a node being a member of an ad hoc communication network, to control an execution of the steps of any of the claims 1-16.

20

25

30

35

40

45

50

55

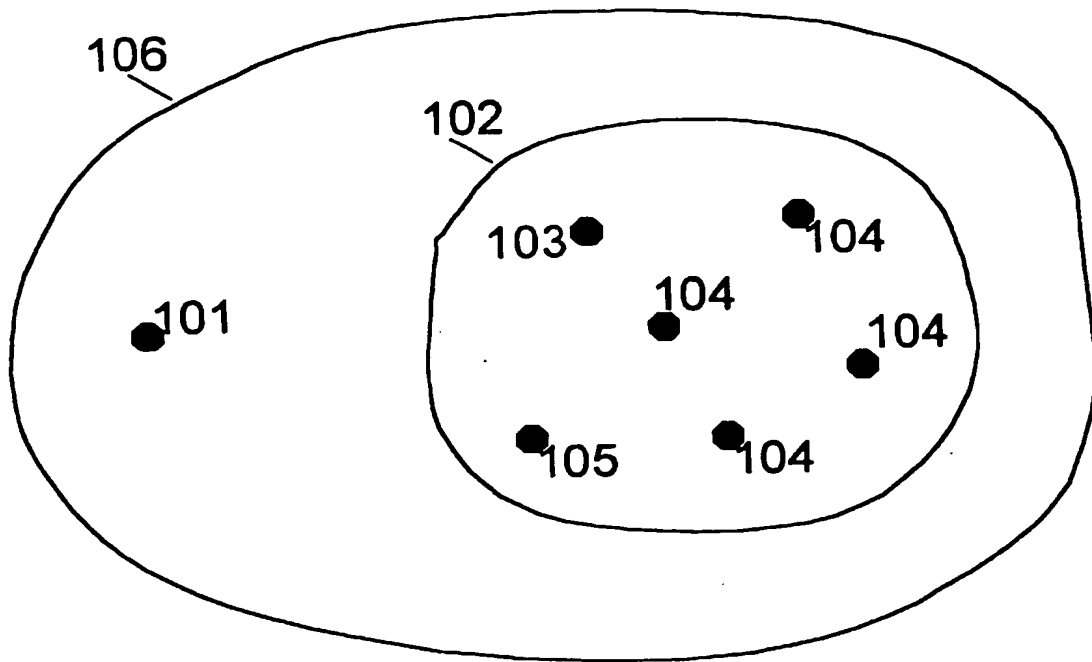


Fig. 1

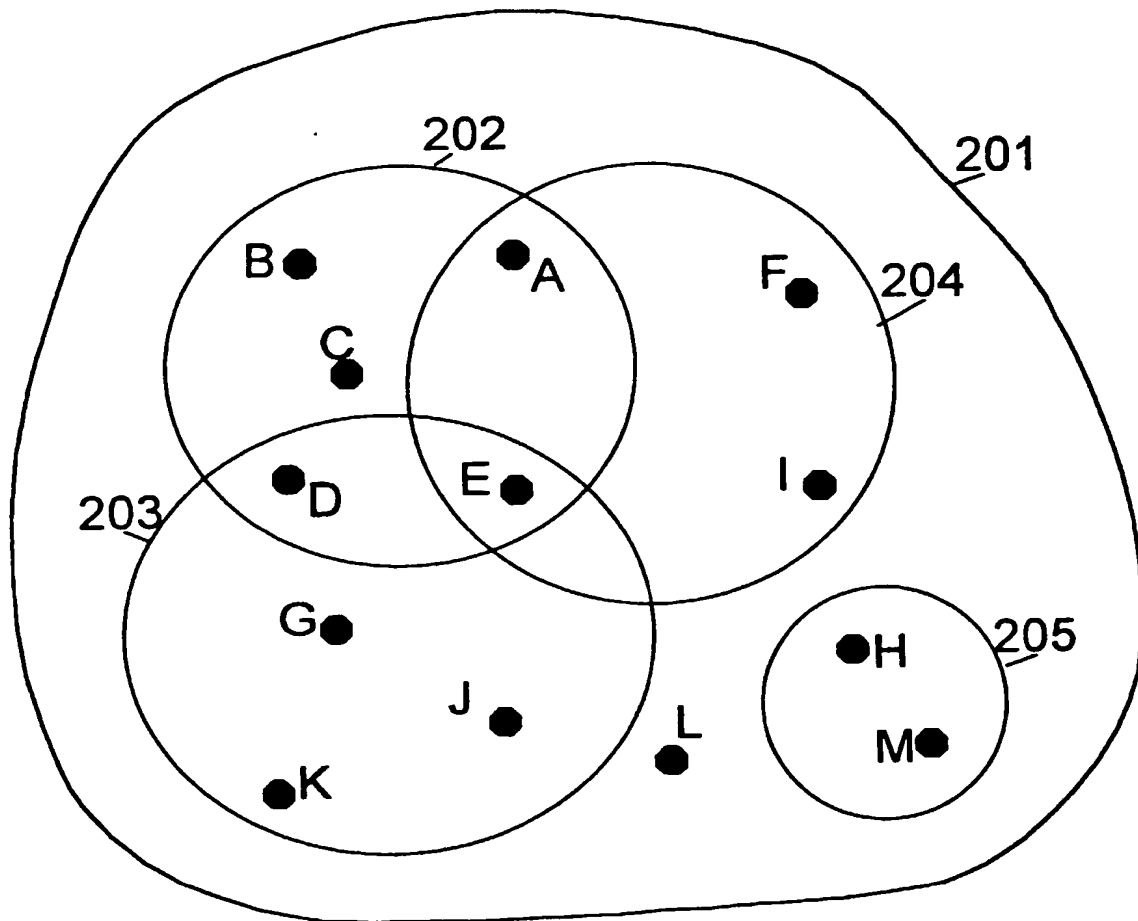


Fig. 2

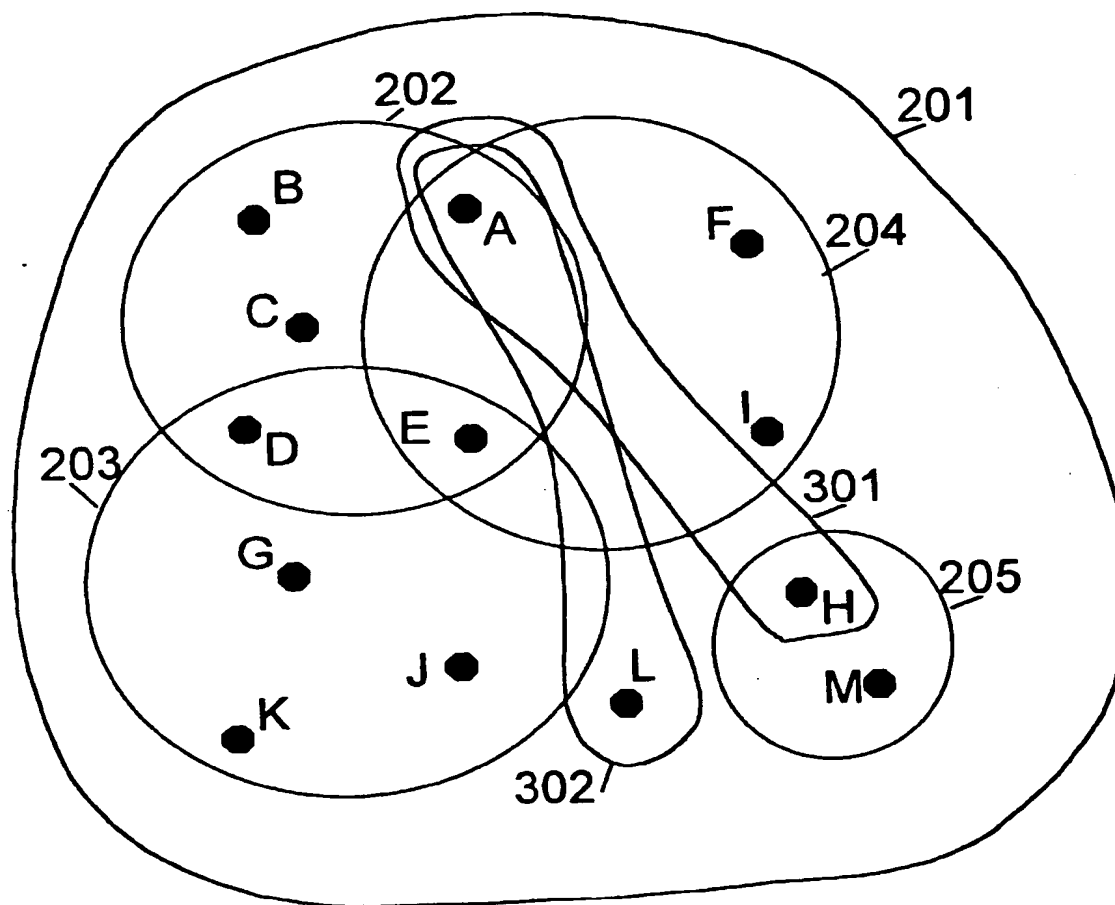


Fig. 3

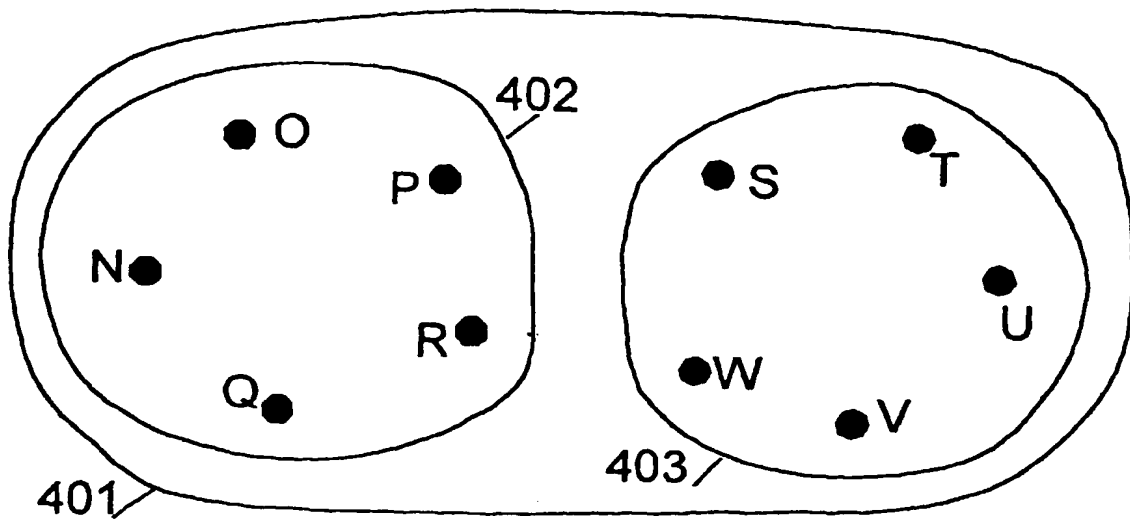


Fig. 4

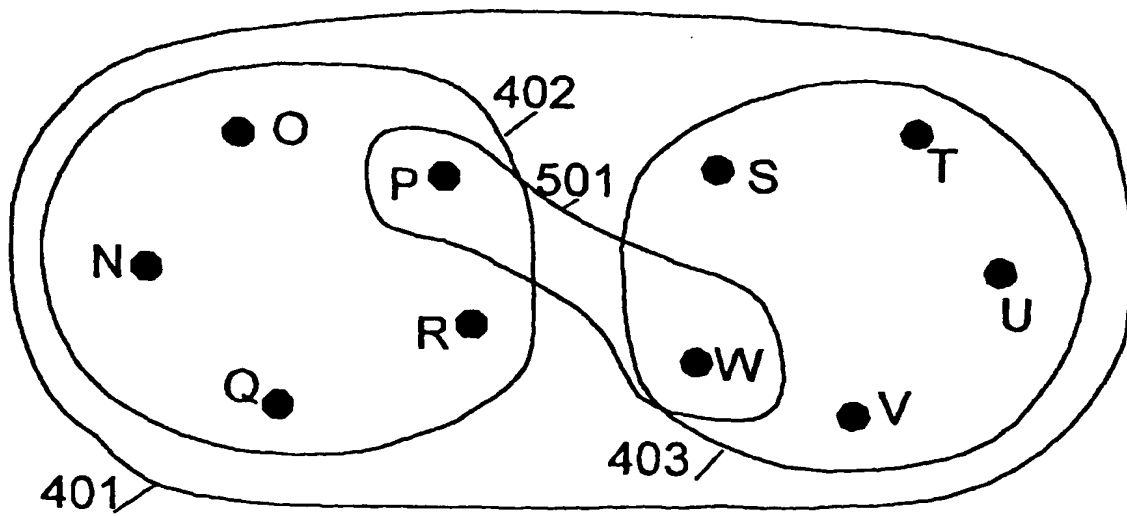


Fig. 5

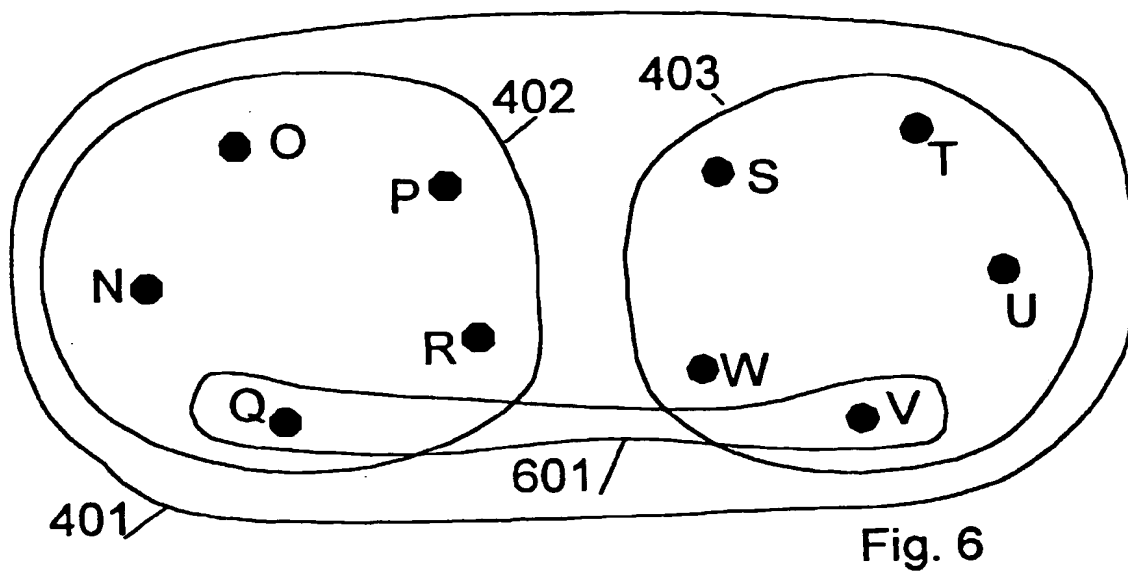


Fig. 6

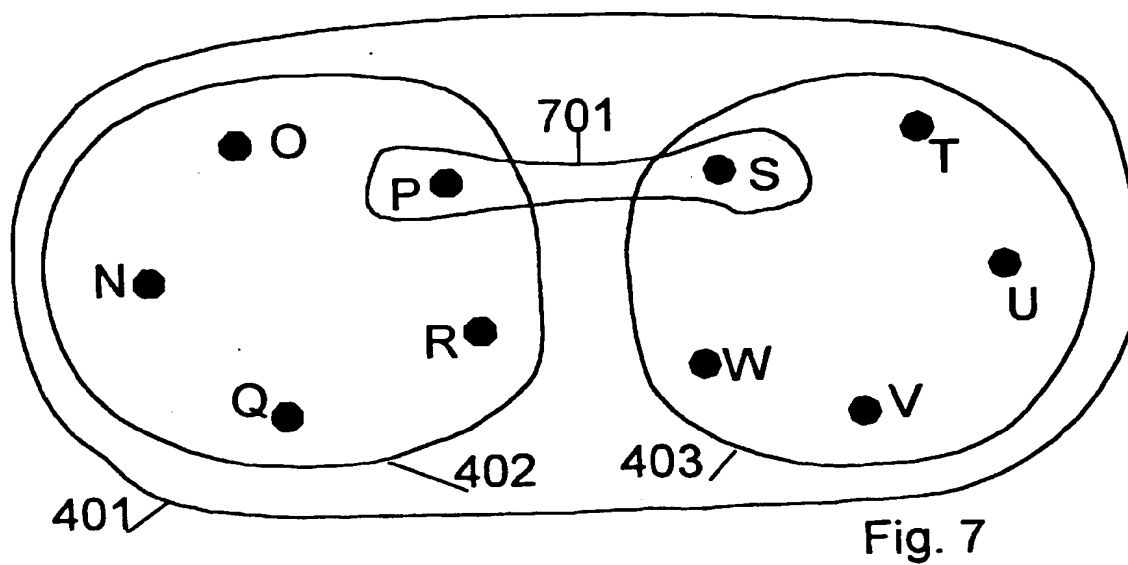


Fig. 7



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 85 0158

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	TANAKA T ET AL: "NOMADIC COMPUTING ENVIRONMENT EMPLOYING WIRED AND WIRELESS NETWORKS" IEICE TRANSACTIONS ON COMMUNICATIONS,JP,INSTITUTE OF ELECTRONICS INFORMATION AND COMM. ENG. TOKYO, vol. E81-B, no. 8, 1 August 1998 (1998-08-01), pages 1565-1573, XP000788462 ISSN: 0916-8516 * page 1566, right-hand column, paragraph 3 - page 1567, right-hand column, paragraph 6; figure 4 * * page 1571 *	1,17,24, 25	H04L9/32 H04L12/28 H04B7/26
A	CHADWICK D W ET AL: "MERGING AND EXTENDING THE PGP AND PEM TRUST MODELS - THE ICE-TEL TRUST MODEL" IEEE NETWORK: THE MAGAZINE OF COMPUTER COMMUNICATIONS,US,IEEE INC. NEW YORK, vol. 11, no. 3, 1 May 1997 (1997-05-01), pages 16-24, XP000689785 ISSN: 0890-8044 * page 17, left-hand column, paragraph 3 - right-hand column, paragraph 2 * * page 18, right-hand column, paragraph 2 - page 21, left-hand column, paragraph 1 * * page 22, left-hand column, paragraph 1 - paragraph 2 *	1-25	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H04L
A	EP 0 939 519 A (NO WIRES NEEDED B V) 1 September 1999 (1999-09-01) * abstract * * column 1, line 1 - column 3, line 54 * --- -/--	1-25	
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 20 July 2000	Examiner Carnerero Álvaro, F
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03/82 (P4/C01)



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 85 0158

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
T	<p>LIDONG ZHOU; HAAS Z J : "Securing ad hoc networks"</p> <p>IEEE NETWORK: THE MAGAZINE OF COMPUTER COMMUNICATIONS, US, IEEE INC. NEW YORK, vol. 13, no. 6, November 1999 (1999-11) - December 1999 (1999-12), pages 24-30, XP002142955 ISSN: 0890-8044 * the whole document *</p> <p>-----</p>	1-25	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 20 July 2000	Examiner Carnero Álvaro, F
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			

EPO FORM 1503 03/82 (P04C01)

EP 1 102 430 A1

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 99 85 0158

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

20-07-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0939519 A	01-09-1999	NL 1008351 C	20-08-1999

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

This Page is inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☒ BLACK BORDERS
- ☒ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☒ FADED TEXT OR DRAWING
- ☐ BLURED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☒ COLORED OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REPERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images
problems checked, please do not report the
problems to the IFW Image Problem Mailbox**

THIS PAGE BLANK (USPTO)